Enhanced photoelectrochemical performance of Bi2S3/Ag2S/ZnO novel ternary heterostructure nanorods

ABSTRACT

The current work investigates the morphology, crystallinity and photoelectrochemical (PEC) performance of bismuth sulfide/silver sulfide/zinc oxide nanorods (Bi2S3/Ag2S/ZnO NRAs) photoelectrodes as prepared at different annealing temperature. ZnO NRAs was initially grown hydrothermally, deposited in sequence with Ag2S and Bi2S3 via successive ionic layer adsorption and reaction (SILAR) method before undergoing the annealing treatment. The optimised photoelectrode (Bi2S3/Ag2S/ZnO NRAs-400 °C) possesses an optical bandgap of 1.60 eV extending the absorption edge of ZnO to visible light spectrum. The current-voltage characterization of Bi2S3/Ag2S/ZnO NRAs photoelectrodes revealed that the photocurrent density and photoconversion efficiency were strongly dependent on the annealing temperature. The PEC study shows that the photoelectrode annealed at 400 °C achieved impressive photocurrent density of 12.95 mA/cm2 at +0.5 V (vs Ag/AgCl/saturated KCl) under 100 mW/cm2 illumination with superior photoconversion efficiency of 12.63%. This improvement is due to the cascade-designed band structure alignment of Bi2S3/Ag2S/ZnO/ITO and to the brilliant role of Ag2S as an intermediate layer that reduced random chance of electron-hole (e−-h+) pairs recombination and improved the electrons collection efficiency. This work is highly anticipated to give contribution on further utilisation of Bi2S3/Ag2S/ZnO NRAs as a promising semiconductor material in PEC related applications.

Keyword: ZnO nanorod arrays; Heterostructure photoanode; SILAR method; Photoelectrochemical cells; Photoconversion efficiency